COLORADO LAGOON:

SEDIMENT TESTING AND MATERIAL DISPOSAL REPORT

KLI.CL-01

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July 30, 2004

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LIST OF ACRONYMS AND ABBREVIATIONS

BPTCP	Bay Protection and Toxics Control Program
NOAA	National Oceanic and Atmospheric Administration
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

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1.0 EXECUTIVE SUMMARY

Colorado Lagoon is listed as an impaired water body on the Los Angeles Regional Water Quality Control Board (RWQCB) 2002 303(d) list. This listing is based on levels of lead, zinc, chlordane, and PAHs in sediments. Bioaccumulation of certain organochlorine pesticides (chlordane, DDT, dieldrin and PCBs) in fish and mussels is also cited as contributing to impairment of the Lagoon. This study provides the first comprehensive examination sediment accumulation and contamination in Colorado Lagoon since it was originally developed.

The primary objectives were to document the current extent of sediment contamination in the Lagoon, assess possible sources and remedies, evaluate potential disposal options for contaminated sediments and develop order of magnitude estimates of removal costs and alternatives.

Testing was conducted in three areas of the Lagoon. These included the western arm (Area CL-1), the southern end at the nexus of the western and northern arms (Area CL-2) and the northern arm (Area CL-2) of the Lagoon. Results indicate a strong contamination gradient with high levels of certain contaminants in the western arm transitioning to much lower levels in the northern arm. Concentrations of many of these contaminants differ by an order of magnitude between Area CL-1 and CL-3. Five metals including cadmium, copper, lead mercury and zinc exhibited this distributional pattern. Among the organic contaminants, DDT compounds, chlordane, dieldrin, PCBs and PAHs also demonstrated this strong gradient.

Lead was found to be the principal constituent of concern with respect to assessing potential disposal or reuse options for sediment from the western arm of the Lagoon (Area CL-1). Two issues were encountered. First, the concentrations of lead in bulk sediments from the western arm were found to exceed EPA's Preliminary Remediation Goals for lead in residential soils of 400 mg/Kg-dry. This limited any reuse on park lands or the golf course. Secondly, the Waste Extraction Test (WET) to test potential mobility resulted in a concentration that was twice the Title 22 STLC criterion causing the sediments to be classified as hazardous material. Since the WET is conducted in an acidic medium of pH 5.0, a modified WET (DI-WET) that uses deionized water at a neutral pH is being conducted as an alternative approach to assessing potential leaching. This test has been used to evaluate lead leaching potential in previous programs including the current Caltrans lead variance. This test typically produces much lower concentrations of soluble lead and has been accepted as an alternative approach for disposal of other marine sediments from the Port of Los Angeles.

Sediments within the western arm of the lagoon (CL-1 area) were found to exceed state requirements for lead and are considered to be hazardous materials. These sediments should be removed west of the foot bridge. The preferred removal method is by excavation in the dry rather than dredging to best manage the sediments. The southernmost (CL-2 area) core samples contain levels of DDT and chlordane above ERLs. Levels are below state standards and can either remain in place, be removed, or beneficially re-used (or a combination thereof). Beneficial re-use requires further study for feasibility. The central (swimming) area is included in removal scenarios.

Material disposal costs vary depending upon approach. Costs reach $5.1 million to haul all contaminated and less contaminated (compromised) material off-site. Costs to haul contaminated material to the Port of Long Beach and re-use some compromised material on-site while hauling off the balance are approximately $2.9 million, and costs to only remove contaminated material and leave compromised material in place are $1.1million.

Disposal options are limited to approved landfill locations for the contaminated material such as off-site at a licensed dump, or within future fill sites at the Port of Long Beach. Any disposal at the Port of Long Beach is subject to future project scheduling by the Port and they have no confirmed schedule at this time, other than that the work is at least two years in the future. None of these materials can be placed in the offshore ocean, the nearshore ocean or on the beach. Permits ranging from the local to federal level are required to complete any material removal and disposal actions. The timeframe for approvals may be up to a year or more.

2.0 INTRODUCTION

The Los Angeles Regional Water Quality Control Board (RWQCB) 2002 303(d) list identifies Colorado Lagoon as impaired due to lead, zinc, chlordane, and PAHs in sediments. Organochlorine pesticides (chlordane, DDT, dieldrin and PCBs) were also cited as contributing to impairment to due bioaccumulation in tissues of fish and mussels. Sediment contamination in Colorado Lagoon was first identified during surveys conducted by the State's Bay Protection and Toxics Control Program (Anderson et al., 1998). The Bay Protection and Toxics Control Program (BPTCP) survey in Colorado Lagoon was conducted in January 1993 at one location. This sample was taken from the western arm of the Lagoon that receives the majority of runoff from the watershed.

The only other available data for sediments in Colorado Lagoon was from a brief survey by Tetra Tech conducted in December 2000. Although chemistry reports were available from this survey, a final report was never completed documenting sampling procedures and specific locations. The laboratory reports indicate that one sample was taken from the western reach of the Lagoon and a second was taken from the eastern or northern reach. Data from both the BPTCP and Tetra Tech surveys of surficial sediments were used to augment information from this study that analyzed sediments from cores.

The purpose of this study was to:

- Document the current extent of sediment contamination in Colorado Lagoon.
- Evaluate probable sources of contamination in the Lagoon
- Assess possible remedies to existing contamination
- Evaluate disposal options for sediments excavated from the Lagoon
- Prepare order-of magnitude cost estimates, disposal capacities, and potential permit requirements for each disposal option

The following is an overview of the organization of this report.

- Section 1.0 is the Executive Summary.
- Section 2.0 introduces the report and provides an overview of the report organization.
- Section 3.0 describes the methods used to collect and analyze sediments from Colorado Lagoon.

- Section 4.0 presents the results of the testing results and provides a comparison of sediment chemistry with ecological benchmarks and hazardous waste criteria. Included is a discussion of potential alternatives for reuse or disposal of accumulated sediment.

- Section 5.0 provides a synthesis of conclusions and preliminary recommendations.

- Section 6.0 is a list of the references cited in this report.

In addition, the following appendices are included with this report:

- Appendix A contains Core Logs that document the lithology of each core and identify the portions of the cores used to develop composite samples for each of three regions in the Lagoon.

- Appendix B contains copies of Analytical Chemistry Report for sediments

3.0 METHODS

This section identifies the specific locations and methods used to obtain, process and analyze sediments from Colorado Lagoon.

3.1 Sampling

Sampling was conducted over a two day period from June 30 through July 1, 2004. The overall approach was designed to provide representative samples from three regions of Colorado Lagoon. A composite sampling approach was used to enable cost-effective sampling and analysis. Three cores were taken within each region of the Lagoon and composited into a single sample for each region. The depth of the cores varied among sites and was determined based upon the lithological characteristics of each core and historical bathymetric records from the site.

3.1.1 Sampling Location

The specific locations of each core are shown in Figure 3-1 and Table 3-1. Cores 1a through 1c comprised the composite sample for the western arm of Colorado Lagoon which receives the most urban runoff. Cores 2a through 2c were taken to represent the intersection of the western.

Table 3-1 Latitude and Longitude of each Core Sample

Site	Latitude[1]	Longitude[1]
1a	33.77222	118.13634
1b	33.77168	118.13560
1c	33.77172	118.13611
2a	33.77073	118.13269
2b	33.77116	118.13226
2c	33.77055	118.13198
3a	33.77281	118.13248
3b	33.77250	118.13200
3c	33.77195	118.13212

1. Based upon NAD83.

Figure 3-1 Locations of each Core Sample in Colorado Lagoon

3.1.2 Vibracore Sampling

A Kinnetic Laboratories Vibracore was used to collect nine sediment core samples. Vibracore sampling was carried out from a custom built, site assembled sampling barge. This barge was equipped with a fixed quadrapod rigging and winch suitable for handling the coring equipment. This system consists of a 4-inch diameter aluminum coring tube, a stainless-steel cutting tip, and a stainless-steel core catcher. The vibrating unit has two counter-rotating motors encased in a waterproof aluminum housing, powered by a three-phase, 240 V generator. Vibracore tubes were lined with FDA approved virgin-grade clear polyethylene core liners.

Figure 3-2 Vibracore Sampling in Colorado Lagoon

Sample location and horizontal positioning were established with a Garmin 76 series Differential GPS navigation system or equivalent, operating in differential mode. Vertical measurements were measured with a graduated lead line. Tidal stage was determined using "Tide.1" software (Micronautics, Inc.). At the request of Kinnetic Laboratories personnel, the flood gates to Colorado Lagoon were closed to maintain a low tide level throughout the sampling effort.

The barge was held stationary over the sampling sites using two diagonally positioned spuds. Once in position, the Vibracore head and tube were lowered through a moon pool in the barge from the quadrapod frame. After successfully penetrating to the desired depth, power was shut down to the vibrating head and the core tube was pulled out of the sediment. A check valve, located on top of the core tube, helped reduce the loss of sediment during pull-out. Once on board, the core cutter and catcher were removed and the polyethylene encased sediment cores were removed from the core tubing. The polyethylene encased cores were then sealed and transported to a shore-side core processing facility.

With the exception of the core tube liners, all sample contact surfaces and compositing tools were stainless steel. Contact surfaces of the sampling and compositing devices were cleaned for each sampling area prior to sample contact. The cleaning protocol consisted of a deionized water triple rinse followed by a Micro-90® soap wash, a 2 N nitric acid triple rinse, and finished with three de-ionized water rinses.

3.1.3 Core Processing

The polyethylene encased cores samples were placed on pre-cleaned PVC core racks, and the polyethylene core tubes were split lengthwise. Once the sediment was exposed, the material that came in contact with the polyethylene core tube liners was removed with a protocol cleaned stainless steel spoon. Cores were measured, photographed, and detailed stratigraphic observations were noted and logged. Lithologic descriptions were made in accordance with the Unified Soil Classification System (USCS) as outlined in ASTM Standard D-2488 (Visual-Manual Procedure).

Figure 3-3 Logging and Compositing of Sediment Core

Core processing included identification by lithology of recently accumulated sediments (i.e. those accumulated since the initial 1935 dredging of Colorado Lagoon) as well as presumably unaltered "virgin" sediments *in-situ* prior to the 1935 excavation of Colorado Lagoon. Recently accumulated sediments and "virgin" sediments were sub-sampled and composited separately for this program. A vertical composite was taken from each core by a vertical scrape protocol along the section of recently accumulated sediments which resulted in equal sub-sampling along the length of the recently accumulated sediment section. In addition, the top six inches of unaltered "virgin" sediment was sampled and composited in a separate compositing vessel.

A separate protocol cleaned compositing vessel was used to homogenize each composite sample prior to sub-sampling. All composite mixing was accomplished manually with a protocol cleaned tool.

Following homogenization, samples for bulk chemistry and elutriate preparation were transferred into appropriate certified pre-cleaned sample containers. Samples were placed on ice immediately following collection and maintained at 2 to 4ºC until analyzed. Samples were handled under Chain-of-Custody protocol, beginning at the time of collection.

3.1.4 Documentation

All samples were handled under Chain of Custody documentation. Samples were marked with pre-printed, self-adhering labels containing unique alphanumeric identifications. Duplicate information was recorded on the Chain of Custody form, which also includes sampling information such as matrix, analysis; analytical methods and detection limits were included on separate pages and submitted to the analytical laboratories with the Chain of Custody forms. Completed Chain of Custody forms will be included with analytical reports in the final report Appendices.

Detailed core logs were prepared for each core sampled. The following information is included on each log: date and time of boring, boring coordinates, core identification, depth penetrated, core length recovered, water depth at the sample site, sediment lithology, and sample intervals (top, new material and bottom “virgin” material). Completed core logs for each sampling location are included in the final report Appendices.

3.2 Chemical Analysis of Sediments

All chemical, physical, and biological analyses were performed by ToxScan, Inc. (Cal-ELAP No. 1515) and Soil Control, Inc., (Cal-ELAP No. 1494). All laboratories involved in this project are State Certified testing laboratories using USEPA, USACE, and CRWQCB approved methodologies.

Sediments were analyzed for the constituents shown and using the methods listed in Table 3-2. Where appropriate, Title 22 criteria used to evaluate whether the sediments should be considered a hazardous waste are also provided in Table 3-2. All sampling and analysis was conducted in a manner consistent with guidelines for dredge material testing methods in the USEPA/USACE Inland Testing Manual (USEPA/USACE, 1998). Samples were extracted and analyzed within specified EPA established holding times. All sample analyses were accomplished with appropriate Quality Control techniques.

The Title 22 criteria require the Waste Extraction Test (WET) if bulk concentrations of a Title 22 constituent range between 10 times the STLC and the TTLC. In the case of lead, this is between 50 mg/Kg-wet and the 1000 mg/Kg-wet level that would automatically classify the material as a hazardous waste. The trigger value of 10 times the STLC is attributable to the fact that there is a 1:10 ratio of soil to extractant in the WET test protocols. The 5 mg/L criterion translates to a total lead value of greater or equal to 50 mg/Kg-wet. The WET calls for extracting soil for 48 hours at a ratio of one part soil to ten parts extractant. The extractant is a solution of 0.2 M sodium citrate adjusted to pH 5.0 +/- 0.1 with sodium hydroxide. These conditions were selected to simulate acid rain and the ability to mobilize contaminants within a landfill situation. The sediments used in this study were assumed to meet the criteria of a Title 22, Type i solid waste that can pass a No. 10 (2 mm) standard sieve. After extraction, the solution is filtered through a 0.45 micron filter prior to analysis. Analytical results are reported as milligrams of lead per liter of extractant.

The Modified WET (DI-WET) was recommended by the California Water Quality Control Board to assess the leachability of waste constituents not disposed at a Class III landfill or in a neutral environment (URS, 1997 and references therein). This test is conducted in exactly the same way as the WET except that the extractant is deionized water instead of the citrate buffer. The pH of the resultant 1:10 mixture is not adjusted to pH 7 but will instead depend upon the initial pH of the soil. This test was only applied to the composite sample from CL-1.

Sample volumes, holding times, containers, and preservation required for these samples are included in Table 3-3.

Table 3-2 Target Analytes, Reporting Limits and Title 22 Criteria

Analytes	Reporting Limit Wet Wt. (mg/kg)	TTLC Wet Wt. (mg/kg)	STLC (mg/L)
Percent Moisture	0.1%		
Total Recoverable Petroleum Hydrocarbons	50		
Sediment Particle Size	-		
Organic Toxic and Bioaccumulative Substances			
Aldrin	0.002	1.4	0.14
gamma-BHC	0.002	4.0	0.4
alpha-Chlordane	0.002	2.5	0.25
gamma-Chlordane	0.002	2.5	0.25
4,4'-DDD	0.002	1	0.1
4,4'-DDE	0.002	1	0.1
4,4'-DDT	0.008	1	0.1
Endrin	0.002	0.2	0.02
Heptachlor	0.002	4.7	0.47
Methoxychlor	0.004	100	10
Toxaphene	0.020	5	0.5
Arochlor-1016	0.020	50	5
Arochlor-1221	0.020	50	5
Arochlor-1232	0.020	50	5
Arochlor-1242	0.020	50	5
Arochlor-1248	0.020	50	5
Arochlor-1254	0.020	50	5
Arochlor-1260	0.020	50	5
Total PCBs	0.020	50	5
Mirex	0.010	21	2.1
Kepone	0.010	21	2.1
2,4-D	5	100	10
Pentachlorophenol	0.75	17	7
2,4,5-T (Silvex)	0.75	10	1
Inorganic Persistent and Bioaccumulative Substances			
Antimony	0.1	500	15
Arsenic	0.1	500	5.0
Barium	0.1	10,000	1000
Beryllium	0.1	75	0.75
Cadmium	0.1	100	1.0
Chromium	0.1	2,500	560
Cobalt	0.1	8.000	80
Copper	0.1	2,500	25
Lead	0.1	1,000	5.0
Mercury	0.02	20	0.2
Molybdenum	0.1	3,500	350
Nickel	0.1	2,000	20
Selenium	0.1	100	1.0
Silver	0.1	500	5
Thallium	0.1	700	7.0
Vanadium	0.1	2,400	24
Zinc	1.0	5,000	250

Table 3.2 Target Analytes, Reporting Limits and Title 22 Criteria

Analytes	Reporting Limits Wet Wt. (mg/kg)	TTLC Wet Wt. (mg/kg)	STLC (mg/L)
Polynuclear Aromatic Hydrocarbons (PAHs)		NA	NA
Naphthalene	0.020		
Acenaphthylene	0.020		
Acenaphthene	0.020		
Fluorene	0.020		
Phenanthrene	0.020		
Anthracene	0.020		
Fluoranthene	0.020		
Pyrene	0.020		
Benzo(a)anthracene	0.020		
Chrysene	0.020		
Benzo(b)fluoranthene	0.020		
Benzo(k)fluoranthene	0.020		
Benzo(a)pyrene	0.020		
Indeno(123-cd)pyrene	0.020		
Dibenzo(a,h)anthracene	0.020		
Benzo(g,h,i)perylene	0.020		
Total PAHs	0.020		

Table 3-3 Sampling Volumes and Storage Requirements

Parameter	Holding Time	Sample Size[a]	Container[b]	Temperature[c]
Grain Size	ASAP	100g	1L WMGJ	4º ± 2ºC
Metals	6 months, Hg 28 days	100g	1L WMGJ	4º ± 2ºC
Pesticides, PAHs	14 days pre-extraction 40 days post extraction	100g	1L WMGJ	4º ± 2ºC
Elutriate Preparation	ASAP (6 months for metals only)		4 x 1L WMGJ	4º ± 2ºC

[a] Required sample sizes for one laboratory analysis. Actual volumes to be collected will be increased to provide a margin of error and allow for retests.
[b] Containers will be completely filled with no head space.
[c] During transport to the laboratory, samples will be stored on ice.
[e] ASAP – As soon as possible, as stated in the analytical method.

4.0 RESULTS AND DISCUSSION

The results of sediment testing are reported both on a wet and dry weight basis. Analytical results reported on a wet weight basis are use to assess whether the sediments would be considered as hazardous waste under California's Title 22 criteria. Analytical results reported on a dry weight basis are use to provide comparisons with various ecological criteria as well as previous testing conducted in Colorado Lagoon.

4.1 Core Depths and Composite Intervals

Complete documentation of core lengths and lithology is provided on boring logs in Appendix A. A summary of penetration depths and sampling intervals is provided in Table 4-1 below.

Core intervals used to develop the composite samples for each area were based upon a combination of bathymetric maps furnished by the City of Long Beach and field interpretation of the core lithology. Core lengths used to develop the composite samples varied substantially among cores within each area due to large differences in the structure of each core. In Area CL-1, a layer of olive gray green clay was determined to mark the lower range of recent deposition. This layer varied from 2.5 to 4.5 feet below ground surface (bgs).

In Area CL-2, core lengths used for the composite ranged from 4.0 to 5.5 feet bgs. The shallowest core composites were obtained from Area CL-3 where the compositing depth ranged from 1.5 to 3.5 feet bgs.

Table 4-1 Core penetration, Recovery and Depth of Composite Section from Each Core

Sampling Area/Core	Core Penetration Depth (ft)	Core Recovery Depth (ft)	Composite Depth (ft)
Area CL-1			
1a	9.0	8.7	3.5
1b	9.0	6.6	2.5
1c	9.0	7.0	4.5
Area CL-2			
2a	9.0	8.5	5.0
2b	9.0	7.0	5.5
2c	9.0	8.5	4.0
Area CL-3			
3a	9.0	7.4	1.5
3b	6.5	5.8	3.0
3c	9.0	8.3	3.5

4.2 Comparison to Title 22 Criteria

Title 22 criteria were used to determine if any of the sediments sampled from Colorado Lagoon contained contaminants at concentrations that were high enough to be considered hazardous waste. For this purpose, the results of all analyses are reported in terms of mg/Kg-wet weight to be consistent with the Total Threshold Limit Concentrations (TTLC) cited in Title 22.

Results of this comparison (Table 4-2) indicate that none of the contaminants exceeded TTLC. Lead, however, was present in two samples at concentrations that were high enough to require WET extractions to determine if elutriate levels exceed the Soluble Threshold Limit Concentration (STLC).

WET extractions were run for lead in sediment composites from the west arm of Colorado Lagoon (CL-1) and those from southernmost site near the connection with Marine Stadium (CL-2). This test (Table 4-3) indicated that elutriate concentrations from the CL-1 composite (11 mg/L) exceeded the STLC of 5 mg/L. Results of this test indicate that sediments in this portion of the Lagoon should be considered to be a hazardous waste material. WET results for CL-2 indicate that sediments sampled from the area of Colorado Lagoon near the tidal gates to Marine Stadium contain contaminants at concentrations below those considered to be hazardous under Title 22 criteria.

Table 4-2 Sediment Analyses (Wet Weight Basis) compared to Title 22 Criteria

Analytes	Reporting Limit Wet Wt. (mg/kg)	CL-1 Top	CL-2 Top	CL-3 Top	TTLC Wet Wt. (mg/kg)	STLC (mg/L)
Percent Moisture	0.1%	40.8	34.6	28.6		
Organic Toxic and Bioaccumulative Substances						
Aldrin	0.002	ND (0.001U)	ND (0.001U)	ND (0.001U)	1.4	0.14
gamma-BHC	0.002	ND (0.001U)	ND (0.001U)	ND (0.001U)	4.0	0.4
alpha-Chlordane	0.002	0.029	ND (0.001U)	ND (0.001U)	2.5	0.25
gamma-Chlordane	0.002	0.032	0.0022	ND (0.001U)	2.5	0.25
4,4'-DDD	0.002	0.023	ND (0.001U)	ND (0.001U)	1	0.1
4,4'-DDE	0.002	0.039	0.01	0.0031	1	0.1
4,4'-DDT	0.008	0.0081	ND (0.001U)	ND (0.001U)	1	0.1
Endrin	0.002	ND (0.001U)	ND (0.001U)	ND (0.001U)	0.2	0.02
Heptachlor	0.002	ND (0.001U)	ND (0.001U)	ND (0.001U)	4.7	0.47
Methoxychlor	0.004	ND (0.002U)	ND (0.002U)	ND (0.002U)	100	10
Toxaphene	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	5	0.5
Arochlor-1016	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1221	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1232	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1242	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1248	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1254	0.020	ND (0.010U)	ND (0.010U)	ND (0.010U)	50	5
Arochlor-1260	0.020	0.058	ND (0.010U)	ND (0.010U)	50	5
Total PCBs	0.020	0.058	ND (0.010U)	ND (0.010U)	50	5
Mirex	0.010	ND (0.010U)	ND (0.010U)	ND (0.010U)	21	2.1
Kepone	0.010	ND (0.010U)	ND (0.010U)	ND (0.010U)	21	2.1
2,4-D	5	ND (0.025U)	ND (0.005U)	ND (0.005U)	100	10
Pentachlorophenol	0.75	ND (0.025U)	ND (0.005U)	ND (0.005U)	17	7
2,4,5-T (Silvex)	0.75	ND (0.025U)	ND (0.005U)	ND (0.005U)	10	1

Table 4-2 Sediment Analyses (Wet-Weight Basis) compared to Title 22 Criteria (continued)

Analytes	Reporting Limit Wet Wt. (mg/kg)	CL-1 Top	CL-2 Top	CL-3 Top	TTLC Wet Wt. (mg/kg)	STLC (mg/L)
Inorganic Persistent and Bioaccumulative Substances						
Antimony	0.1	1.0	0.50	0.40	500	15
Arsenic	0.1	4.4	4.0	3.5	500	5.0
Barium	0.1	202	352	76	10,000	1000
Beryllium	0.1	0.32	0.32	0.27	75	0.75
Cadmium	0.1	1.2	0.43	0.27	100	1.0
Chromium	0.1	20	19	15	2,500	560
Cobalt	0.1	3.6	4.0	2.9	8.000	80
Copper	0.1	33	18	10	2,500	25
Lead	0.1	**242**	**53.6**	28	1,000	5.0
Mercury	0.02	0.20	0.11	0.038	20	0.2
Molybdenum	0.1	7.1	5.7	4.8	3,500	350
Nickel	0.1	11	9.3	6.3	2,000	20
Selenium	0.1	0.31	0.18	0.23	100	1.0
Silver	0.1	0.71	1.1	0.20	500	5
Thallium	0.1	0.54	0.29	0.26	700	7.0
Vanadium	0.1	33	35	28	2,400	24
Zinc	1.0	157	64	33	5,000	250

Bolded values indicate results that exceeded 10x the STLC and thus required DiWET extractions to assess solubility

Table 4-3 Results and Comparison of WET Elutriates with Title 22 Criteria

Site	Total Lead (mg/Kg)	WET Lead (mg/L)	STLC (mg/L)
CL-1 Top	242	11	5.0
CL-2 Top	53.6	2.1	5.0

4.3 Adequacy of Sample Depths and Comparison with Ecological Criteria and Previous Data Sets

The complete data set is summarized Tables 4-4 and 4-5. All chemical data are based upon dry weight to provide direct comparison with available ecological benchmark data and historical measurements. Data from the composite core samples are then compared to previous surveys of surface sediments in Colorado Lagoon (Table 4-6).

4.3.1 Adequacy of Sampling Depths

To aid in the evaluation of sediment test data, chemical concentrations of contaminants found within the sediments were compared to sediment quality guidelines (Long et. al., 1995) developed by NOAA. These guidelines were used to screen sediments for contaminant concentrations that might cause biological effects and to identify sediments for further toxicity testing. For any given contaminant the Effects Range Low (ERL) guideline represents the 10th percentile concentration value in the NOAA database that might be expected to cause adverse biological effects and the Effects Range Medium (ERM) reflects the 50th percentile value in the database.

Three metals (copper, lead and zinc) are known to be good indicators of urban runoff. Analysis of these three metals was used to provide an indication of whether depths of the composite samples were sufficient to penetrate past sediments deposited in the Lagoon since the initial dredging effort. These metals were analyzed from the lower six inches of a one foot section located just below the segment of each core used for the composite sample. Results of these confirmation analyses are indicated in Table 4-3 as CL-1 Bottom, CL-2 Bottom and CL-3 Bottom.

In all three cases, concentrations of these three metals were below the ERL. In at least one case, however, results of the confirmation samples suggest evidence of concentrations that may be influenced by urbanization of the Colorado Lagoon watershed. The concentration of lead in the CL-1 Bottom composite was 40 mg/Kg-dry compared to 14 and 13 mg/Kg-dry at the other two sites. This suggests that one or more of the three composite core lengths at this site may not have fully penetrated through the layer of sediments deposited since the original dredging effort. Nevertheless, it was obviously close to the transition point since the concentration of this confirmation sample was less than 8 percent of the concentration of lead in the overlying sediment.

The concentration of zinc in confirmation samples from Area CL-2 was similar to the concentration in overlying sediments (103 vs 97 mg/Kg-dry). Zinc measured in the confirmation sample from Area CL-3 was notably higher than in the composite samples (72 vs 46 mg/Kg-dry). Concentrations of copper were relatively uniform in the confirmation samples (22 to 28 mg/Kg-dry) but were still higher than overlying sediments in Area CL-3.

Overall, depths of the composite samples appear to adequately represent the sediments deposited since the initial dredging of the Lagoon. The variability in the vertical composition of sediments in the three cores taken within each of the three sampling areas combined with the evidence that lead was still present in the Area CL-1 confirmation samples at levels twice those in the two areas suggests that a conservative approach should be used in any effort to remove these sediments.

In Area CL-1, the maximum depth of contamination is estimated to be 6 feet. This is 6 inches past the depth of the deepest sample used for confirmation testing. In Area CL-2, concentrations of lead were very low in the confirmation sample but zinc concentrations remained consistent with the overlying material. The length of the deepest composite layer in this area was 5.5 feet. There was little evidence of urban influences in the confirmation composite. Use of the deepest core depth of 5.5 feet plus a 1 foot overdredge (total of 6.5 feet) should provide a sufficient buffer to assure removal of any contaminated sediments. Depositional sediments in Area CL-3 were 1.5 to 4.0 feet. Sediments in this area did not show substantial evidence of contamination at levels of concern (refer to following sections).

4.3.2 Comparison with Ecological Benchmarks

Results (Tables 4-4) demonstrate a clear pollution gradient within Colorado Lagoon. The western arm contains high levels of lead as well as several organochlorine pesticides. Concentrations of total lead in Area CL-1 (409 mg/Kg-dry) exceed EPA Region IX Preliminary Remediation Goals (http://www.epa.gov/region09/waste/sfund/prg/index.htm) for residential soils (400 mg/Kg-dry). Based upon this criterion alone, reuse on site would not be an advisable option. Lead concentrations drop dramatically in Area CL-2 (81 mg/Kg-dry) and Area CL-3 (40 mg/Kg-dry). DDT compounds, chlordane and dieldrin show similar trends with ERM exceedances for each of these compounds in Area CL-1. Concentrations of DDT compounds went from 81 ug/Kg-dry in Area CL-1 to 4.3 ug/Kg-dry in Area CL-3. This was the only compound or group of compounds to exceed the ERLs in Area CL-3. The contamination gradient for chlordane was exceptionally dramatic with concentrations of 105 ug/Kg-dry in Area CL-1, 3.3 ug/Kg-dry in Area CL-2 and below detection limits (<2.8 ug/Kg-dry) in Area CL-3.

Dieldrin, one of the compounds cited as causing impairment in tissues, was only detected in the western arm of the Lagoon where it was present in excess of three times the ERM. PCBs were only detected in the western arm of the Lagoon with concentrations just above the ERL. PAHs followed the same trend with phenathrene and acenaphthene being the only PAHs to exceed ERLs in Area CL-2. None of the PAH compounds exceed these ERLs in Areas CL-2 and CL-3

4.3.3 Comparison with Previous Data

Previous sediment sampling in Colorado Lagoon was conducted by the Bay Protection and Toxics Control Program (BPTCP) and Tetra Tech, EMI. The BPTCP sampled surficial sediments from one site in the western arm of Colorado Lagoon in January of 1993. BPTCP data are included the BPTCP database available on the State Water Resources Control Board web site. Data were analyzed in a report by Anderson et al (1998) titled Sediment Chemistry, Toxicity, and Benthic Community Conditions in Selected Water Bodies of the Los Angeles Region, Final Report. Tetra Tech sampled two locations in the Lagoon in December 2000. One station (CL-West) was located in the western arm of the Lagoon. The second (CL-East) was located in the northern arm of the Lagoon. These sites roughly correspond to Areas CL-1 and CL-3. Sediment analyses performed by Tetra Tech were also base upon surficial samples.

The results of sediment analyses in the western arm of the Lagoon reported by BPTCP (1998) and Tetra Tech (2000) showed a high degree of similarity for metals and organochlorine pesticides. Both copper and lead exceeded ERMs in both data sets while five to six other metals exceeded ERLs. Concentrations of DDT compounds, chlordane and dieldrin were all well above ERMs in both sets of samples. PCBs, however, were detected at 100.5 mg/Kg-dry in 1993 but below detection limits (<25 mg/Kg-dry) in 2000.

Concentrations of PAHs in surficial sediments from the western arm of the Lagoon declined substantially between 1993 and 2000. Total PAH concentrations measured in 2000 were half of those reported by the BPTCP in 1993. Total PAH concentrations in cores from the current investigation were 15 percent of the concentrations measured in 1993 in surface sediments and only two PAH compounds exceeded ERLs.

Contaminant concentrations in sediments from the two sites sampled by Tetra Tech in 2000 also indicated a spatial gradient going from high concentrations in the western portion of the Lagoon to substantially lower concentrations in the northern (eastern) portion of the Lagoon. Nevertheless, differences between these two areas were not as extreme as found in core composites from these two regions.

Table 4-4 Composite Samples from Colorado Lagoon compared to NOAA ERL and ERMs

	Units	ERL	ERM	SAMPLE IDENTIFICATION CL-1 Bottom	CL-1 Top	CL-2- Bottom	CL-2 Top	CL-3 Bottom	CL-3 Top
Conventionals									
Percent Moisture	Percent (wet)			41	41	33	34.6	40.2	28.6
TRPH	mg/kg (dry)				490		ND (76U)		ND (70U)
Solids, Percent	Percent (wet)			59	59	67	65.4	59.8	71.4
Metals									
Antimony	mg/kg (dry)				1.7		0.77		0.57
Arsenic	mg/kg (dry)	8.2	70		7.5		6.1		4.9
Barium	mg/kg (dry)				342		538		107
Beryllium	mg/kg (dry)				0.53		0.49		0.37
Cadmium	mg/kg (dry)	1.2	9.6		**2.1**		0.65		0.38
Chromium	mg/kg (dry)	81	370		34		29		21
Cobalt	mg/kg (dry)				6.1		6.0		4.1
Copper	mg/kg (dry)	34	270	22	**55**	28	27	26	15
Lead	mg/kg (dry)	47	218	40	**409**	14	**81.3**	13	40
Mercury	mg/kg (dry)	0.15	0.71		**0.33**		**0.17**		0.053
Molybdenum	mg/kg (dry)				12		8.7		6.7
Nickel	mg/kg (dry)	21	51.6		18		14		8.9
Selenium	mg/kg (dry)				0.53		0.28		0.32
Silver	mg/kg (dry)	1	3.7		**1.2**		**1.7**		0.28
Thallium	mg/kg (dry)				0.91		0.45		0.36
Vanadium	mg/kg (dry)				56		53		39.
Zinc	mg/kg (dry)	150	410	63	**266**	103	97	72	46

Red highlighting indicates ERM exceedances. Yellow highlighting indicates ERL exceedances.
ND=Not Detected, U indicates the reporting limit associated with contaminants that were below reporting limits in the sample.

Table 4.4 Composite Samples from Colorado Lagoon compared to NOAA ERL and ERMs (continued)

	Units	ERL	ERM	SAMPLE IDENTIFICATION CL-1 Bottom	CL-1 Top	CL-2 Bottom	CL-2 Top	CL-3 Bottom	CL-3 Top
Herbicides									
2,4,5-TP (Silvex)	ug/kg (dry)				ND (422U)		ND (76U)		ND (70U)
2,4-D	ug/kg (dry)				ND (422U)		ND (76U)		ND (70U)
Pentachlorophenol (PCP)	ug/kg (dry)				ND (422U)		ND (76U)		ND (70U)
PAHs									
Naphthalene	ug/kg (dry)				15		ND (31U)		ND (28U)
Fluorene	ug/kg (dry)	19	540		ND (34 U)		ND (31U)		ND (28U)
Phenanthrene	ug/kg (dry)	240	1500		**253**		18		9.0J
Anthracene	ug/kg (dry)	85	1100		ND (34 U)		7.9J		ND (28U)
Acenaphthene	ug/kg (dry)	16	500		**17J**		6.0J		ND (28U)
Acenaphthylene	ug/kg (dry)	44	640		12J		ND (31U)		ND (28U)
Fluoranthene	ug/kg (dry)	600	5100		372		53		31
Pyrene	ug/kg (dry)	665	2600		625		73		34
Benzo(a)anthracene	ug/kg (dry)	261	1600		ND (34 U)		ND (31U)		ND (28U)
Chrysene	ug/kg (dry)	384	2800		ND (34 U)		ND (31U)		ND (28U)
Benzo(a)pyrene	ug/kg (dry)	430	1600		ND (34 U)		ND (31U)		ND (28U)
Benzo(b)fluoranthene	ug/kg (dry)				ND (34 U)		ND (31U)		ND (28U)
Benzo(k)fluoranthene	ug/kg (dry)				ND (34 U)		ND (31U)		ND (28U)
Dibenzo(a,h)anthracene	ug/kg (dry)	63.4	260		ND (34 U)		ND (31U)		ND (28U)
Benzo(g,h,i)perylene	ug/kg (dry)				ND (34 U)		ND (31U)		ND (28U)
Indeno(1,2,3-cd)pyrene	ug/kg (dry)				ND (34 U)		ND (31U)		ND (28U)
Total Low MW PAHs	ug/kg (dry)	552	3160		282		32		9.0
Total High MW PAHs	ug/kg (dry)	1700	9600		1279		158		73
Total PAHs	ug/kg (dry)	4022	44792		1561		190		82
Phthalates									
Benzyl butyl phthalate	ug/kg (dry)				ND (34 U)		ND (31U)		34
bis-(2-Ethylhexyl)phthalate	ug/kg (dry)				3600		410		260
Diethyl phthalate	ug/kg (dry)				47		42		65
Dimethyl phthalate	ug/kg (dry)				19		ND (31U)		3.2J
Di-n-butyl phthalate	ug/kg (dry)				ND (34 U)		38		27
Di-n-octyl phthalate	ug/kg (dry)				ND (34 U)		ND (31U)		ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 4.4 Composite Samples from Colorado Lagoon compared to NOAA ERL and ERMs (continued)

	Units	ERL	ERM	SAMPLE IDENTIFICATION CL-1 Bottom	CL-1 Top	CL-2- Bottom	CL-2 Top	CL-3 Bottom	CL-3 Top
DDT Compounds									
4,4'-DDD	ug/kg (dry)	2	20		ND (3.4U)		**3.5**		ND (2.8U)
4,4'-DDE	ug/kg (dry)	2.2	27		**67**		**16**		**4.3**
4,4'-DDT	ug/kg (dry)	1	7		**14**		ND (12U)		ND (11U)
Total DDT	ug/kg (dry)	1.58	46.1		**81**		**20**		**4.3**
Chlordane Compounds									
alpha-Chlordane	ug/kg (dry)				50		ND (3.1U)		ND (2.8U)
gamma-Chlordane	ug/kg (dry)				55		3.3		ND (2.8U)
Heptachlor	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Heptachlor epoxide	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Total Chlordane	ug/kg (dry)	0.5	6.0		**105**		**3.30**		ND (2.8U)
Other OC Pesticides									
Aldrin	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
alpha-BHC	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
beta-BHC	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
delta-BHC	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
gamma-BHC (Lindane)	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Dieldrin	ug/kg (dry)	0.02	8		**27**		ND (3.1U)		ND (2.8U)
Endosulfan I	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Endosulfan II	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Endosulfan sulfate	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Endrin	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Endrin aldehyde	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Endrin ketone	ug/kg (dry)				ND (3.4U)		ND (3.1U)		ND (2.8U)
Kepone	ug/kg (dry)				ND (17U)		ND (15U)		ND (14U)
Methoxychlor	ug/kg (dry)				ND (6.8U)		ND (6.1U)		ND (5.6U)
Mirex	ug/kg (dry)				ND (17U)		ND (15U)		ND (14U)
Toxaphene	ug/kg (dry)				ND (34U)		ND (31U)		ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 4.4 Composite Samples from Colorado Lagoon compared to NOAA ERL and ERMs (continued)

	Units	ERL	ERM	SAMPLE IDENTIFICATION CL-1 Bottom	CL-1 Top	CL-2- Bottom	CL-2 Top	CL-3 Bottom	CL-3 Top
PCBs									
PCB-1016 (Aroclor 1016)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1221 (Aroclor 1221)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1232 (Aroclor 1232)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1242 (Aroclor 1242)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1248 (Aroclor 1248)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1254 (Aroclor 1254)	ug/kg (dry)	23	180		ND (34 U)		ND (31U)		ND (28U)
PCB-1260 (Aroclor 1260)	ug/kg (dry)	23	180		**98**		ND (31U)		ND (28U)
Total PCBs	ug/kg (dry)	22.7	180		**98**		ND (31U)		ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 4-5 Particle Size Composition of Sediment Cores from Colorado Lagoon

Particle Fraction	CL-1 Bottom	CL-1 Top	CL-2 Bottom	CL-2 Top	CL-3 Bottom	CL-3 Top
Sand (0.062-4.0 mm)	**11.1 %**	**47.7 %**	**20.7 %**	**43.6 %**	**30.2 %**	**70.1 %**
Silt/Clay (<0.062 mm)	**88.9 %**	**52.3**	**79.3 %**	**56.4 %**	**69.8 %**	**29.9 %**

Table 4-6 Comparison with Historical Data Sets

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
Conventionals									
Percent Moisture	Percent (wet)						41	34.6	28.6
TRPH	mg/kg (dry)				2000	440	490	ND (76U)	ND (70U)
Solids, Percent	Percent (wet)				39	41	59	65.4	71.4
Metals									
Antimony	mg/kg (dry)			2.7			1.7	0.77	0.57
Arsenic	mg/kg (dry)	8.2	70	**9.5**	**10**	**8.9**	7.5	6.1	4.9
Barium	mg/kg (dry)						342	538	107
Beryllium	mg/kg (dry)						0.53	0.49	0.37
Cadmium	mg/kg (dry)	1.2	9.6	**2.0**	**2.8**	**1.5**	**2.1**	0.65	0.38
Chromium	mg/kg (dry)	81	370	56	55	51	34	29	21
Cobalt	mg/kg (dry)						6.1	6.0	4.1
Copper	mg/kg (dry)	34	270	**87**	**120**	**100**	**55**	27	15
Lead	mg/kg (dry)	47	218	**510**	**390**	**180**	**409**	**81**	40
Mercury	mg/kg (dry)	0.15	0.71	**0.36**	0.02U	0.02U	**0.33**	**0.17**	0.053
Molybdenum	mg/kg (dry)						12	8.7	6.7
Nickel	mg/kg (dry)	21	51.6	**34**	**36**	**32**	18	14	8.9
Selenium	mg/kg (dry)						0.53	0.28	0.32
Silver	mg/kg (dry)	1.0	3.7	0.62	**1.4**	**1.8**	**1.2**	**1.7**	0.28
Thallium	mg/kg (dry)						0.91	0.45	0.36
Vanadium	mg/kg (dry)						56	53	39.
Zinc	mg/kg (dry)	150	410	**690**	**600**	**340**	**266**	97	46

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 4-6 Comparison with Historical Data Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
Herbicides									
2,4,5-TP (Silvex)	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
2,4-D	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
Pentachlorophenol (PCP)	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
PAHs									
Naphthalene	ug/kg (dry)						15	ND (31U)	ND (28U)
Fluorene	ug/kg (dry)	19	540	**95.6**	ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
Phenanthrene	ug/kg (dry)	240	1500	**1770**	230	54	**253**	18	9.0J
Anthracene	ug/kg (dry)	85	1100	**188**	43	25	ND (34 U)	7.9J	ND (28U)
Acenaphthene	ug/kg (dry)	16	500	**113**	ND (25U)	ND (25U)	**17J**	6.0J	ND (28U)
Acenaphthylene	ug/kg (dry)	44	640		ND (25U)	ND (25U)	12J	ND (31U)	ND (28U)
Fluoranthene	ug/kg (dry)	600	5100	**2330**	530	150	372	53	31
Pyrene	ug/kg (dry)	665	2600	**2210**	**1300**	190	625	73	34
Benzo(a)anthracene	ug/kg (dry)	261	1600	**701**	**330**	100	ND (34 U)	ND (31U)	ND (28U)
Chrysene	ug/kg (dry)	384	2800	**889**	**510**	140	ND (34 U)	ND (31U)	ND (28U)
Benzo(a)pyrene	ug/kg (dry)	430	1600	**691**	410	130	ND (34 U)	ND (31U)	ND (28U)
Benzo(b)fluoranthene	ug/kg (dry)				590	140	ND (34 U)	ND (31U)	ND (28U)
Benzo(k)fluoranthene	ug/kg (dry)				480	140	ND (34 U)	ND (31U)	ND (28U)
Dibenzo(a,h)anthracene	ug/kg (dry)	63.4	260	**125**	ND (180U)	ND (170U)	ND (34 U)	ND (31U)	ND (28U)
Benzo(g,h,i)perylene	ug/kg (dry)				410	ND (200U)	ND (34 U)	ND (31U)	ND (28U)
Indeno(1,2,3-cd)pyrene	ug/kg (dry)				610	ND (170U)	ND (34 U)	ND (31U)	ND (28U)
Total Low MW PAH	ug/kg (dry)	552	3160	**738**[1]	273	79	282	32	9.0
Total High MW PAH	ug/kg (dry)	1700	9600	**9301**[1]	**5170**	990	1279	158	73
Total PAH	ug/kg (dry)	4022	44792	**10039**[1]	5453	1069	1561	190	82
Benzyl butyl phthalate	ug/kg (dry)				640	250	ND (34U)	ND (31U)	34
bis-(2-Ethylhexyl)phthalate	ug/kg (dry)				14000	1800	3600	410	260
Diethyl phthalate	ug/kg (dry)				48	39	47	42	65
Dimethyl phthalate	ug/kg (dry)				31	ND (25U)	19	ND (31U)	3.2J
Di-n-butyl phthalate	ug/kg (dry)				180	91	ND (34U)	38	27
Di-n-octyl phthalate	ug/kg (dry)				310	ND (250U)	ND (34U)	ND (31U)	ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

1. Totals include additional PAHs not analyzed in the current program

Table 4-6 Comparison with Historical Data Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
DDT Compounds									
4,4'-DDD	ug/kg (dry)	2	20	**40.6**	**46**	**8.9**	ND (3.4U)	**3.5**	ND (2.8U)
4,4'-DDE	ug/kg (dry)	2.2	27	**89.9**	**110**	**44**	**67**	**16**	**4.3**
4,4'-DDT	ug/kg (dry)	1	7	**50.9**	**11**	**2.7**	**14**	ND (12U)	ND (11U)
Total DDT	ug/kg (dry)	1.58	46.1	**181.4**[2]	**167**	**55.6**	**81**	**20**	**4.3**
Chlordane Compounds									
alpha-Chlordane	ug/kg (dry)			70.3	73	13	50	ND (3.1U)	ND (2.8U)
gamma-Chlordane	ug/kg (dry)				61	15	55	3.3	ND (2.8U)
Heptachlor	ug/kg (dry)			1.5	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Heptachlor epoxide	ug/kg (dry)			2.5	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Total Chlordane	ug/kg (dry)	0.5	6.0	**74.3**[2]	**134**	**28**	**105**	**3.30**	ND (2.8U)
Other OC Pesticides									
Aldrin	ug/kg (dry)			8.2	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
alpha-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
beta-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
delta-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
gamma-BHC (Lindane)	ug/kg (dry)			0.8	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Dieldrin	ug/kg (dry)	0.02	8	**24.3**	**19**	**3.2**	**27**	ND (3.1U)	ND (2.8U)
Endosulfan I	ug/kg (dry)			0.7	ND (5.1U)	ND (4.9U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endosulfan II	ug/kg (dry)			2.8	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endosulfan sulfate	ug/kg (dry)			2.7	ND (25U)	ND (25U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin	ug/kg (dry)				17	5.7	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin aldehyde	ug/kg (dry)				ND (2.5U)	ND (2.5U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin ketone	ug/kg (dry)				ND (2.8U)	2.0	ND (3.4U)	ND (3.1U)	ND (2.8U)
Kepone	ug/kg (dry)						ND (17U)	ND (15U)	ND (14U)
Methoxychlor	ug/kg (dry)				ND (25U)	ND (25U)	ND (6.8U)	ND (6.1U)	ND (5.6U)
Mirex	ug/kg (dry)						ND (17U)	ND (15U)	ND (14U)
Toxaphene	ug/kg (dry)				ND (76U)	ND (74U)	ND (34U)	ND (31U)	ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

1. Total Chlordane including cis-nonachlor, trans-nonachlor, and oxychlordane equaled 134.5 ug/Kg-dry.
2. Total DDT including 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT equaled 208 ug/Kg-dry.

Table 4-6 Comparison with Historical Data Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
PCBs									
PCB-1016 (Aroclor 1016)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1221 (Aroclor 1221)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1232 (Aroclor 1232)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1242 (Aroclor 1242)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
PCB-1248 (Aroclor 1248)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1254 (Aroclor 1254)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
PCB-1260 (Aroclor 1260)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	**98**	ND (31U)	ND (28U)
Total PCBs	ug/kg (dry)	22.7	180	**100.5**	ND (25U)	ND (25U)	**98**	ND (31U)	ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

4.4 Evaluation of Potential Sources of Contamination

The spatial distribution of contaminants in Colorado Lagoon clearly show that the major contaminants of concern (COCs) are introduced into the western reach. Portions of the watershed that contribute to loads in the northern reach of the Lagoon appear to contribute relatively minor loads of COCs. The subbasin that contributes to the northern arm of the Lagoon is half the size of the subbasin the drains to the western arm. In addition, the subbasin for the northern arm consists of two primary land use categories. Land use in this area is roughly 1/3 park lands/golf course and 2/3 residential. The subbasin that drains to the western arm of the Lagoon is a mix of residential, commercial, transportation corridors, institutional and park lands/golfcourse land use activities.

The primary COCs identified in the lagoon are lead and the three groups of organochlorine pesticides (DDT compounds, chlordane and dieldrin). Secondary COCs include PCBs and a number of metals including cadmium, copper, mercury, silver and zinc. The primary source of lead in urban drainages is typically historical use of leaded gasoline. Although today lead in gasoline has been greatly reduced, gasoline still contains lead and continues to be a source of lead in the environment. The organochlorine pesticides are considered legacy contaminants in that manufacturing and use of the compounds has been prohibited for many years. Due to the persistence of these compounds, they are still found in soils and storm drain systems. Recent surveys in the San Francisco Bay area (Kinnetic Laboratories, Inc./EOA Inc., 2002) have demonstrated that these compounds are still found in relatively high concentrations in sediments in stormdrains and catchbasins. These contaminants are strongly associated with the fine grained sediments. Although, concentrations of these substances are rarely detected in stormwater runoff, these contaminants are commonly encountered in areas where sediments transported by stormwater runoff settle and accumulate over time.

The adjacent golf course contributes runoff to both the western and northern reaches of the Lagoon. The largest contributions from the golf course would be expected to enter the northern reach where it comprises at least 1/3 of the total area of the subbasin. The golf course also contributes runoff to the western arm of the Lagoon but it comprises only a small portion of the total area of the subbasin. The much higher quality of sediments in the northern reach may indicate that the golf course is not now and has not historically been a major source of metals, organochlorine pesticides or PAHs.

4.5 Assessment of Potential Remedies to Existing Contamination

A primary objective of the feasibility study is to “evaluate the need to remove contaminated sediments”. The criteria to determine this need are based on: 1) the requirement to address 303(d) listed contaminants, 2) hazards to human health, and 3) contaminant effects on the current habitat and potential habitats to be restored in the future. Sediment removal can also be driven by the need to improve water circulation. This report will not address the water circulation criteria; this will be analyzed using the hydrology/hydraulics model and the results will be reported in the alternatives evaluation report deliverable.

The potential remedies to address the existing contamination include;

- dredging or removal by other means of the contaminated sediments; and
- in-place encapsulation (sequestering) of the contaminated sediments.

Dredging or removal by other means (in the dry by earthmoving equipment) will be discussed in more detail in the following section. Sequestering the contaminants by capping the material may not be a desirable option because of difficulties posed by the constrained lagoon geometry generating additional costs to create the capped feature, the long-term monitoring costs, and the potential for public controversy. It is estimated that 2-3 feet thick of material would be required, covering a large portion of the lagoon bottom; this thickness is necessary to prevent bioturbation of benthic organisms. This would also decrease the water volume of the lagoon and thus potentially affect the lagoon’s water circulation. Any capping type approach would require an ongoing monitoring effort to assure that the integrity of the cap is preserved. Such monitoring can add substantially to the cost. This encapsulation option will be further assessed as part of the alternatives report deliverable.

4.6 Disposal Options for Sediments Excavated from the Lagoon

As discussed previously, the western arm (Area CL-1) core sediments were found to exceed the Title 22 STLC for lead and thus are considered to be hazardous materials. In addition, the western arm sediments exceed the EPA Preliminary Remediation Goal (PRG) for lead. Based on the potential hazards to human health and adverse affects on the habitat in this area, there is a definite need to address contaminated sediments in the western arm, (the lagoon area to the west of the foot bridge). Based on the Title 22 violations, the only available options for material from the western arm are disposal at an off-site landfill approved to accept hazardous material or at a beneficial reuse facility (e.g. the Port of Long Beach).

The southernmost (CL-2 area) core samples were found to contain levels of DDT and chlordane above ERLs; because of the adverse affects on the habitat and perhaps public perception associated with swimming and wading, this area may also warrant material removal. However, the material from this area does not violate Title 22 thresholds and thus more options exist to leave the material in place, remove and reuse the material on-site, remove and dispose of it at a landfill or a combination of these actions. A potential on-site reuse application would be to create bird nesting islands within the lagoon or create bermed or mounded buffer areas along the lagoon perimeter; these options will be further assessed as part of the alternatives report.

The spatial distribution of the contaminants strongly suggest that a gradient exists such that contamination levels are highest at the western arm, become lower towards the southern section and are lowest at the northern arm tip. Interpolation between the western arm results and the southern section results indicates that the central (swimming) area probably also contains contaminated material. This area, (east of the foot bridge extending to the culvert inlet), has been included in some material removal scenarios. Further sediment sampling may be warranted as part of future engineering to verify the existence of contaminants in this area.

In order to determine the material removal depth of material removal, the core samples at each location were analyzed based on the location (depth) of accumulated sediments. Review of coring depths and sediment chemistry in each region were used to estimate appropriate removal depths. Removal depths were estimated to be -6 ft in Area CL-1 and -6.5 ft in Area CL-2. The reasoning for selection of these depths is addressed in Section 4.1. Figure 4-1 shows preliminary contours used to determine the material removal and disposal quantities and cost estimates, Special attention was given to: 1) providing stable side slopes, 2) maximizing (flattening) slopes to provide acceptable habitat for wetland organisms and 3) minimizing disturbance to existing mudflat habitat on the northern shore. The material removal plan (Figure 4-1) purposely maintains the current waterline footprint; future alternatives may propose to expand the footprint for habitat and/or circulation improvement reasons, causing this plan to be refined.

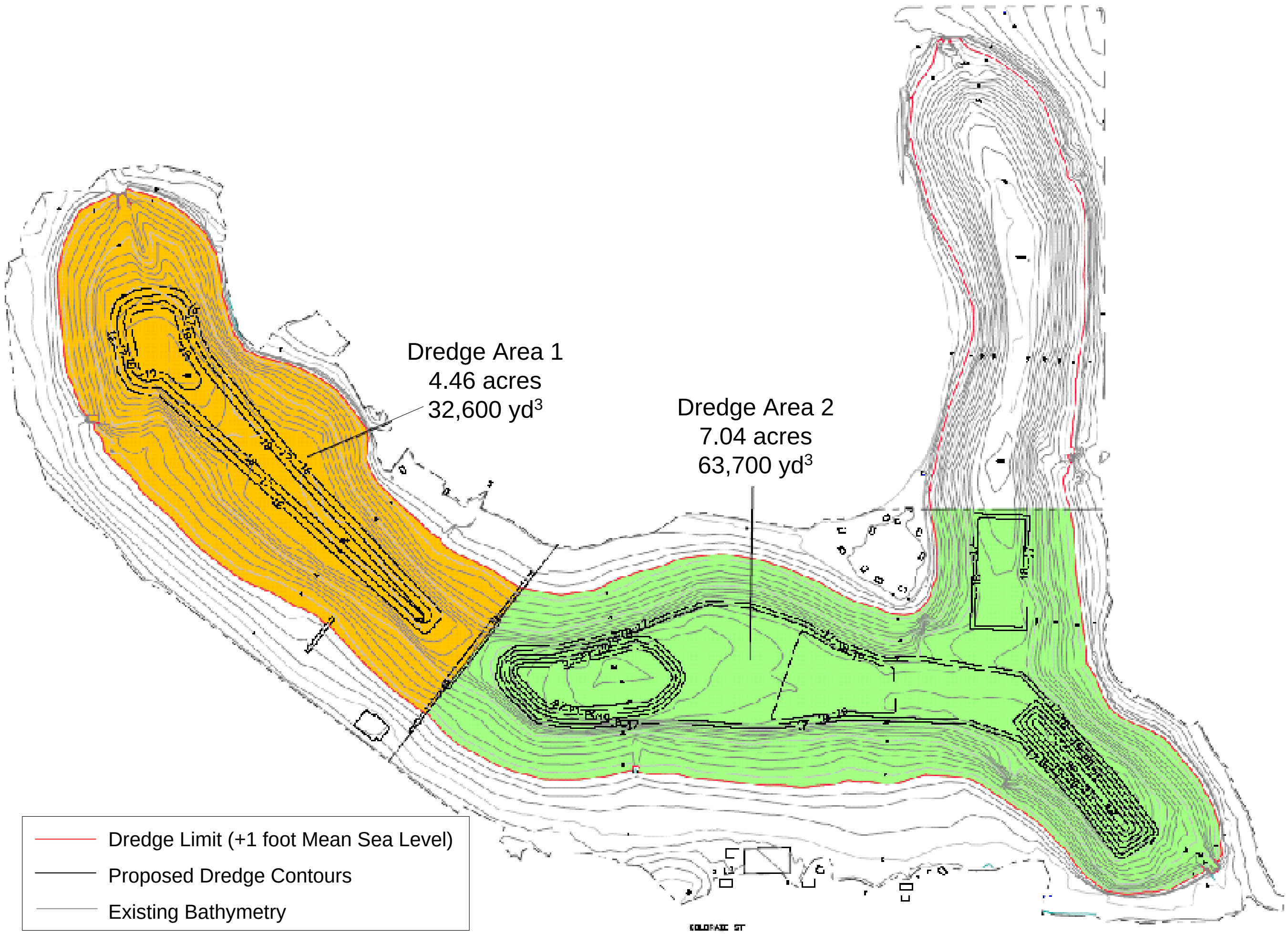

Figure 4-1 Map of Material Removal Area

4.7 Cost Estimates, Disposal Capacities and Potential Permit Requirements for Each Disposal Option.

4.7.1 Cost Estimates and Disposal Capacities

Cost estimates were generated for planning purposes to understand the range of possible actions to address the lagoon sediment as part of restoration. This analysis provides order of magnitude costs for material disposal. Restoration alternatives are to be addressed in subsequent work. Three material removal and/or reuse scenarios were considered to generate order-of-magnitude cost estimates. The scenarios include:

> ***Scenario 1:*** Remove all contaminated material (within Area CL-1) or compromised material (less contaminated material within Area CL-2) and haul it off-site for disposal at an appropriate disposal facility;
>
> ***Scenario 2:*** Remove all contaminated material (within Area CL-1) and haul it to the Port of Long Beach at the Pier J South Landfill or Middle Harbor, and re-use one-fourth of the compromised material (within Area CL-2) on-site in berms or mounded perimeter habitat areas while the balance of compromised material is hauled to the same location at the Port of Long Beach. The feasibility to re-use material on-site needs verification in subsequent studies of alternatives.
>
> ***Scenario 3:*** Remove all contaminated material (within Area CL-1) and haul it to the Port of Long Beach at the Pier J South Landfill or Middle Harbor, and leave all of the compromised material (within Area CL-2) in-place without disturbance.

The costs for each scenario are summarized in Tables 4-7 through 4-9. The cost to haul all contaminated and/or compromised material from the lagoon in Scenario 1 is $5.1 million. This represents the greatest level of disturbance of any action. The cost to remove contaminated material and re-use one-fourth of the compromised material in Scenario 2 is $2.9, assuming the City feels compelled to remove compromised sediment, which may not be necessary as the sediment does not pose a significnat risk to human health or the environment. The other action considered thus far is simply removing the contaminated sediment, and leaving the remaining material on-site with no modification in Scenario 3 for a cost of $1.1 million. This likely represents the least impact scenario for the City at this time. Consideration was given to leaving the contaminated material in the lagoon and capping it in-place, but that option would be technically difficult and possibly costly, and much more controversial and is therefore not developed further in this discussion.

Other possible disposal options such as offshore ocean, nearshore ocean and beach disposal are not appropriate for the contaminated sediment. The offshore ocean option may be feasible for the compromised sediment but that cost is greater than placing it at the Port of Long Beach. It should be noted that the Port of Long Beach does not have a schedule for their need for the material associated with a project. They indicated that they would not be able to receive the material prior to two years in the future. This period may would be sooner than the lagoon project could come on-line as this time period may be required for the future phases of environmental review and permitting, and final engineering for construction that must occur prior to the start of construction.

The disposal options considered in this study have the capacity to receive the entire volume of 96,300 cubic yards of material possibly requiring disposal. The only option with limited capacity is reusing the material on-site. Due to area constraints of the lagoon perimeter, the project team estimates that no more than approximately one-quarter of the volume in CL-2 can be used, or approximately 16,000 cubic yards or less.

Table 4-7 Construction Cost Estimates, Scenario 1

COLORADO LAGOON MATERIAL DISPOSAL ANALYSES
CONSTRUCTION COST ESTIMATE
SCENARIO 1
AREA 1 HAULED TO OFFSITE CLASS I LANDFILL
AREA 2 HAULED TO OFFSITE CLASS II LANDFILL

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$50,000.00	$50,000
2	Dewater Areas 1 and 2	1	LS.	$20,000.00	$20,000
3	Excavate Area 1	32,600	CY	$6.00	$195,600
4	Excavate Area 2	63,700	CY	$6.00	$382,200
5	Haul Area 1 Material to a Class I Landfill (Westmorland in San Diego County)	32,600	CY	$40.00	$1,304,000
6	Haul Area 2 Material to a Class II Landfill (Bee Canyon in Orange County)	63,700	CY	$25.00	$1,592,500
	Subtotal Items				$3,544,300
	Contingency (25%)				$886,075
	Engineering, Design, Supervision, and Administration (15%)				$531,645
	Permitting (5%)				$177,215
	TOTAL				**$5,139,235**

ASSUMPTIONS
1. The lagoon is drained, dewatered and excavated in the dry using conventional earthmoving equipment.
2. The material is trucked in a rig with a capacity of 8 cubic yards per load for a transport time of 5 hours round-trip to the Westmorland Fill.
3. Trucking costs are $40 per hour to either Westmorland or Bee Canyon.
4. Tipping fees at the landfills are assumed to be $50 per truck at both Westmorland and Bee Canyon (to be verified).
5. The construction period is five months.

Table 4-8 Construction Cost Estimates, Scenario 2

COLORADO LAGOON MATERIAL DISPOSAL ANALYSES
CONSTRUCTION COST ESTIMATE
SCENARIO 2
AREA 1 HAULED TO THE PORT OF LONG BEACH
AREA B COMBINED RE-USE ON-SITE
AND HAULED TO THE PORT OF LONG BEACH

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$50,000.00	$50,000
2	Dewater Areas 1 and 2	1	LS.	$20,000.00	$20,000
3	Excavate Area 1	32,600	CY	$6.00	$195,600
4	Excavate Area 2	63,700	CY	$6.00	$382,200
5	Haul Area 1 Material to the Port of Long Beach	32,600	CY	$15.00	$489,000
6	Re-Use Area 2 Material On-Site (Assuming a Capacity of One-Fourth of the Volume)	15,925	CY	$9.00	$143,325
7	Haul the Balance of Area 2 Material to the Port of Long Beach	47,775	CY	$15.00	$716,625
	Subtotal Items				$1,996,750
	Contingency (25%)				$499,188
	Engineering, Design, Supervision, and Administration (15%)				$299,513
	Permitting (5%)				$99,838
	TOTAL				**$2,895,288**

ASSUMPTIONS

1. The lagoon is drained, dewatered and excavated in the dry using conventional earthmoving equipment.
2. The material is trucked in a rig with a capacity of 8 cubic yards per load for a transport time of 1 hour round-trip to the Port of Long Beach
3. Trucking costs are $40 per hour.
4. No tipping fees are required
5. The construction period is five months.

Table 4-9 Construction Cost Estimates, Scenario 3

COLORADO LAGOON MATERIAL DISPOSAL ANALYSES
CONSTRUCTION COST ESTIMATE
SCENARIO 3
AREA 1 HAULED TO THE PORT OF LONG BEACH
AREA 2 MATERIAL LEFT IN PLACE AT THE LAGOON

ITEM NO.	ITEM DESCRIPTION	QUANTITY	UNIT	UNIT COST	SUBTOTAL
1	Mobilization & Demobilization	1	LS.	$50,000.00	$50,000
2	Dewater Area 1	1	LS.	$20,000.00	$20,000
3	Excavate Area 1	32,600	CY	$6.00	$195,600
4	Haul Area 1 Material to the Port of Long Beach	32,600	CY	$15.00	$489,000
	Subtotal Items				$754,600
	Contingency (25%)				$188,650
	Engineering, Design, Supervision, and Administration (15%)				$113,190
	Permitting (5%)				$37,730
	TOTAL				**$1,094,170**

ASSUMPTIONS

1. The lagoon is drained, dewatered and excavated in the dry using conventional earthmoving equipment.
2. The material is trucked in a rig with a capacity of 8 cubic yards per load for a transport time of 1 hour round-trip to the Port of Long Beach
3. Trucking costs are $40 per hour.
4. No tipping fees are required
5. The construction period is five months.

4.7.2 Permit Requirements

The project will require permits from several agencies with jurisdiction over the activity. The same permit requirements apply to any of the actions described above. Coordination with and approval by NOAA Fisheries (formerly the National Marine Fisheries Service) and the U.S. Fish & Wildlife Service will also have to occur as part of the permitting effort. Permit requirements are specified below.

Sections 10 and 404 Permit from the U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) has jurisdiction over "waters of the U.S." from the Clean Water Act, the Rivers and Harbors Act, and the National Environmental Policy Act (NEPA). The USACE issues a Sections 10 and 404 permit for construction in such waters, and placement of fill or dredging in waters of the U.S., respectively. The USACE analyzes the project under NEPA for environmental effects and can either prepare a Finding of No Significant Impact (FONSI) document for non-impacting projects, an Environmental Assessment (EA) for projects that may cause impacts but that are mitigable, or an Environmental Impact Statement (EIS) for projects to cause significant impacts that are not mitigable. This project will likely require an EA or EIS. The USACE also requires the RWQCB permit to be secured. Securing the Sections 10 and 404 permit can take up to twelve months and no fee is required.

California Environmental Quality Act

The City of Long Beach is considered the Lead Agency for the project and will have to meet requirements of the California Environmental Quality Act (CEQA). CEQA requires projects of a certain magnitude and impact to be reviewed for environmental impacts. The type of document to be prepared depends on the degree of potential environmental impact identified in the CEQA Initial Study. A Negative Declaration (ND) is prepared for projects will not cause significant impacts, while a Mitigated Negative Declaration (MND) is required for projects that may cause significant impacts that can be mitigated. An Environmental Impact Report (EIR) is prepared for projects causing potentially significant impacts that cannot be mitigated. This project may be appropriate for a Mitigated Negative Declaration or an EIR. The time period for completion and certification of an MND is approximately four to six months depending on preparation and review periods. Public review is 30 days long. An EIR may take twice that time period to complete and certify.

Section 401C Certification from the Regional Water Quality Control Board

The Regional Water Quality Control Board (RWQCB) permits activities covered under Section 401 of the Clean Water Act. The RWQCB issues a Section 401C Certification for construction projects proposing fill or material removal in jurisdictional waters. The permit is a prerequisite for securing permits from federal agencies. The RWQCB considers whether existing water quality will be impaired by the project and requires conditions to minimize possible impacts, such as monitoring. They can also require mitigation if impacts are documented. Approximately three months is required to secure the permit assuming one month for clarification of the initial permit application, and two months to process the permit. A fee will also be required and varies depending on the proposed action.

Waste Discharge Requirements from the Regional Water Quality Control Board

The RWQCB also permit removal and discharge of sediments under Waste Discharge Requirements under the Clean Water Act. Approximately three months is also required to secure the permit and this permitting can occur concurrently with other RWQCB permits. A fee will also be required and varies depending on the proposed action.

Dewatering Permit from the Regional Water Quality Control Board

The RWQCB permits dewater activities under the Clean Water Act. As with the other RWQCB permits, approximately three months is required to secure the permit and this permitting can occur concurrently with other RWQCB permits. A fee will also be required and varies depending on the proposed action.

Stormwater Permits from the Regional Water Quality Control Board

The project will require the General Construction Activity Storm Water Permit from the RWQCB. The permit requires completion of a Notice of Intent to Discharge (NOI) form, and preparation and implementation a Storm Water Pollution Prevention Plan (SWPPP) mainly requiring adequate erosion control measures.

Coastal Development Permit from the City of Long Beach

The City has permitting authority over activities within the Coastal Zone according to their Local Coastal Program (LCP). The City will examine the project's consistency with the LCP, and potential effects to public access, recreation and the environment. The permit can take four to six months to secure, depending on the level of potential controversy or impact.

Coastal Development Permit from the California Coastal Commission

The California Coastal Commission (CCC) has jurisdiction over activities within the Coastal Zone, extending approximately one mile inland. They retain the right to appeal a local decision and can take action if deemed appropriate. The CCC examines the project's consistency with the Coastal Act, and potential effects to public access, recreation and the environment. If needed, the permit can also take four to six months to secure. Requirements to secure this permit are possession of the RWCQB permit and a certified CEQA document.

Streambed Alteration Agreement from the State Department of Fish and Game

A 1600-1601 Streambed Alteration Agreement from the State Department of Fish and Game (CDFG) will be required by the CDFG to modify the lagoon. This agreement requires 3 to 6 months to secure, and will be required prior to USACE approval. Typically, the CDFG reviews the project, assesses impacts and benefits, and negotiates conditions as appropriate.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

Historical data combined with more complete information from this survey were used to evaluate the magnitude and extent of sediment contamination from Colorado Lagoon, assess probable sources, and develop a preliminary set of recommendations for addressing sediment contamination in the Lagoon.

Based upon sediment sampling conducted throughout the lagoon as well as historical

1. Sediment sampling results indicate a strong contamination gradient with high levels of certain contaminants in the western arm transitioning to much lower levels in the northern arm. Concentrations of many of these contaminants differ by an order of magnitude between the western and northern reaches of the Lagoon.

2. The primary constituents of concern (COCs) identified in the lagoon are lead and the three groups of organochlorine pesticides (DDT compounds, chlordane and dieldrin). Secondary COCs include PCBs and a number of metals including cadmium, copper, mercury, silver and zinc.

3. Concentrations of lead in sediments from the western reach of the Lagoon exceed EPA Region 9 Principal Remediation Goals for residential soil.

4. Results of a Waste Extraction Test (WET) indicate that levels of lead exceed the Soluble Threshold Limit Concentration (STLC) under Title 22 guidelines. These results indicate that the material would be classified as a hazardous waste. Further testing is being conducted using the modified WET of DI-WET test to examine leachability under a neutral pH. This test typically produces much lower concentration of soluble lead and has been accepted as an alternative approach for disposal of other marine sediments from the Ports of Los Angeles and Long Beach.

5. The primary source of contaminants appears to be the western subbasin which is twice the area of the eastern subbasin and which differs substantially in land use characteristics. The eastern subbasin consists primarily of park/golf course and residential land use. The western subbasin consists of a mix of residential, commercial, transportation corridors, institutional and park lands/golf course land use activities.

6. Material disposal costs vary depending upon approach. Assuming the lagoon is drained and excavated in the dry, costs reach $5.1 million to haul all contaminated (hazardous) and less contaminated (compromised) material off-site as a worst case. Costs to haul it to the Port of Long Beach and re-use compromised material on-site are approximately

$2.9 million, and costs to only remove contaminated material and leave compromised material are $1.1 million.

7. Disposal options are limited to approved landfill locations for the contaminated material such as off-site at a licensed dump, or within future fill sites at the Port of Long Beach. Any disposal at the Port of Long Beach is subject to future project scheduling by the Port and they have no confirmed schedule at this time, other than that the work is at least two years in the future. None of these materials can be placed in the offshore ocean, the nearshore ocean or on the beach.

8. Contaminated materials could potentially be sequestered in place and capped with clean materials, but constrained lagoon geometry creates technical challenges to configuring such a deposit which could cause this option to be nearly as costly as removing the material entirely. The potential for public controversy over this option may also render it less desirable. This option warrants further consideration in a future study.

9. Less contaminated materials (compromised material) can also be disposed of at upland landfills and the Port of Long Beach. They may also be able to be re-used on-site but this option requires further investigation. Alternatively, these materials can left in place and not disturbed because they do not appear to adversely effect lagoon habitat or hydrology.

10. Permits ranging from local to federal levels are required to complete any material removal and disposal action. The timeframe for approvals may be up to a year or more.

6.0 REFERENCES

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APPENDIX A

Core Logs

APPENDIX B

Laboratory Reports